Alexis Balayre

Future Position Prediction for Pressure Refuelling Port of Commercial Aircraft

School of Aerospace, Transport and Manufacturing
Computational and Software Techniques in Engineering

MSc
Academic Year: 2023–2024

Supervisors: Dr Boyu Kuang and Dr Stuart Barnes
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This thesis is submitted in partial fulfilment of the requirements for the degree of MSc.

Academic Integrity Declaration

I declare that:

- the thesis submitted has been written by me alone.
- the thesis submitted has not been previously submitted to this university or any other.
- that all content, including primary and/or secondary data, is true to the best of my knowledge.
- that all quotations and references have been duly acknowledged according to the requirements of academic research.

I understand that to knowingly submit work in violation of the above statement will be considered by examiners as academic misconduct.

Abstract

Replace with your abstract text of not more than 300 words.

Keywords:
Replace with at least 6, semicolon seperated keywords (not contained within the thesis title) – this makes the thesis searchable.

Acknowledgements

The author would like to thank . . .

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List of Abbreviations

SATM	School of Aerospace, Technology and Manufacturing
SEEA	School of Energy, Environment and Agrifoods
CDS	Cranfield Defence and Security

Chapter 1

Introduction

Ground pressure refuelling is a standard method used to refuel commercial aircraft safely and efficiently. This process involves using a hydrant system, which consists of underground fuel pipelines connected to a network of fuel hydrants located at aircraft parking positions [1]. The hydrant system is supplied with fuel from storage tanks, typically located near the airport [2].

When an aircraft is ready for refueling, a hydrant dispenser vehicle, also known as a hydrant truck or cart, is connected to the hydrant pit using a flexible hose [3]. The hydrant dispenser vehicle is equipped with a pressure control valve, a flow meter, and a filtration system to ensure that the fuel meets the required quality standards [4].

The refueling process begins by connecting the hydrant dispenser vehicle to the aircraft's fuel panel using another flexible hose [3]. The pressure control valve on the hydrant dispenser vehicle is then used to regulate the fuel pressure and flow rate, ensuring that the fuel is delivered to the aircraft at the appropriate pressure and volume [4].

One of the main advantages of pressure ground refueling is its efficiency. This method allows for high fuel flow rates, which can significantly reduce aircraft turnaround times [1]. Additionally, the use of underground pipelines eliminates the need for fuel trucks, reducing traffic congestion and the risk of accidents on the apron [2].

Safety is another critical aspect of pressure ground refueling. The hydrant system is designed with multiple safety features, such as emergency shutdown valves and leak detection systems, to minimise the risk of fuel spills and fires [4]. Moreover, the hydrant dispenser vehicles are equipped with safety devices, such as dead man switches and bonding cables, to prevent incidents during the refueling process [3].

Figure 1.1: Pressure Refuelling of a Commercial Aircraft. Source: Tom Boon/Simple Flying

The aviation industry is undergoing a significant transformation with the advent of intelligent airports based on highly automated systems. Among these, automated refuelling systems play a crucial role in ensuring efficient and accurate refuelling of aircraft. However, one of the main challenges of this automation process is the accurate detection of the aircraft's refuelling port, which is relatively small and can easily be obscured by other visual elements on or near an aircraft. Scanning the entire area of each video frame is both time-consuming and inaccurate. It is therefore essential to develop a more efficient and accurate method of locating the refuelling port.

This thesis aims to address this challenge by developing a new AI model that uses the temporal relationships between successive frames of a video to predict the location of the refuelling port in subsequent frames. By focusing the analysis on the most relevant areas of the video sequence, this approach has the potential to optimise both the speed and accuracy of the refuelling system.

Specific objectives of this thesis include conducting a comprehensive review of state-of-the-art object detection and tracking methods, designing and developing a real-time computer vision system capable of accurately detecting and tracking the pressurised refuelling port of a commercial aircraft, the implementation and evaluation of deep learning time series models for future position prediction, the integration of Extended Kalman Filtering (EKF) into deep learning models to improve the accuracy and robustness of future position predictions, and the development of a real-time framework for predicting the future position of the pressurised refuelling port.

By achieving these objectives, this thesis aims to make a significant contribution to the development of intelligent airport systems and to improve the efficiency and accuracy of automated refuelling systems at airports, while reducing computing power requirements. The proposed framework has the potential to be applied in various scenarios, such as different lighting conditions, angles and orientations of refuelling ports, making it a versatile and effective solution to the challenges of automated refuelling systems.

Chapter 2

Literature Review

2.1 Automated Refulling Systems in the Aviation Industry

2.1.1 Introduction to Automated Refuelling

2.1.2 Current Technologies and Methods

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2.1.4 Role of Computer Vision in Automated Refuelling

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2.3.1 Deep Learning Models for Time-Series Prediction

2.3.2 Long Short-Term Memory (LSTM) Networks

2.3.3 Recurrent Neural Networks (RNN)

2.3.4 Transformer Models

2.3.5 Applications in Predictive Modelling

2.3.6 Challenges and Future Research Directions

References

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Appendix A

Ethical Approval Letter

Insert your Ethical Approval Letter as the first appendix.

Appendix B

Extra Data

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